## A.2.13 ASTROBIOLOGY SCIENCE AND TECHNOLOGY INSTRUMENT DEVELOPMENT

### 1. Scope of Program

The Astrobiology Science and Technology Instrument Development (ASTID) program element requests proposals to develop instrumentation capabilities that will help meet Astrobiology science requirements on future space flight missions, as well as unique Astrobiology science objectives on Earth. Selected activities are expected to advance the development of scientific instruments or instrument components to the point where the instruments could be credibly proposed in response to future flight opportunity announcements, although proposals to build flight-qualified hardware are not allowed for this program element. In addition, the development of laboratory instruments designed to open a new area of study for Astrobiology will also be considered.

#### 1.1 Background

In the summer of 1998, NASA and the science community created a roadmap for Astrobiology that describes the scientific goals and objectives for this program, which is now available on the Astrobiology web site at http://astrobiology.arc.nasa.gov/roadmap. The instrumentation developed from research supported through this program element is meant to address two fundamental questions in Astrobiology, namely, "How does life begin and evolve?" and "Does life exist elsewhere in the Universe?" The specific objectives that could be addressed by new spacecraft instrumentation are, for example:

- To determine whether the atmosphere of the early Earth, hydrothermal systems, or exogenous matter were significant sources of organic matter;
- To search for evidence of ancient climates, extinct life, and potential habitats for extant life on Mars;
- To determine the presence of chemical precursors and potential habitats for life in the outer Solar System; and
- To determine if compounds of biological significance are present beyond our Solar System.

This expected improvement to Astrobiology science and technology will further two broad objectives of the Office of Space Science: First to determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life; and second, to chart the distribution of past and present life-sustaining environments and search for evidence of past and present life.

#### 1.2 ASTID Goals for Flight Instruments and Technologies

To take advantage of the wide range of mission opportunities, including aircraft and other suborbital platforms, Astrobiology requires the development of innovative technologies. Because of limited spacecraft accommodations, scientific instruments often must be very small and robust and have low power and telemetry bandwidth requirements. The mass, volume, and power constraints will be even more severe for instruments that would fly on so-called "scouts," by which is meant small, multiple-copy landers for multiple sites that

may be used in some of the planetary exploration programs. In most cases, instruments on spacecraft need to operate autonomously or allow teleoperation while conducting complex *in situ* sample analyses. Successful instruments will have to operate in environments often characterized by extremes of temperatures, pressures, dormant periods while in transit to other worlds, gravity, high-g landing impacts, vibration, and/or high radiation. Sensors already exist that range from fingernail to matchbook sizes, and a wide array of miniaturized chemical laboratories exist that can fit on a compact disk; however, relatively few are ready to be proposed successfully for space flight.

Major targets of Astrobiology interest include Mars, Europa, Titan, comets, Space Station, Earth, other planetary systems, and dense interstellar or molecular clouds. ASTID program emphasis will be placed on proposals that are relevant to missions with the greatest potential of meeting Astrobiology goals for which instruments have not yet been selected or on which instruments may still be changed. Furthermore, support can be provided for long lead time definition studies, for innovative approaches that may provide entirely new classes of instruments, for the development of new enabling technologies for missions further in the future, and/or for development studies that may advance the technology for a wide range of instrumentation applications. It is anticipated that to develop potential space flight instruments, some approaches will require novel instrument concepts while other approaches will focus on reductions in mass, volume, power requirements, and/or costs of existing technologies. NASA also recognizes that some approaches may require field testing to improve instrument utility and robustness, and, therefore, such activities may be a legitimate part of a proposal to this program.

Although proposals in all areas relevant to Astrobiology goals and objectives will be considered for the ASTID program, a particular need in the following areas is currently recognized:

- The handling of samples collected for astrobiological objectives;
- The *in situ* detection of possible biomarkers such as isotopic and organic measurements;and
- Development of novel access technologies such as drilling into rock or deep drilling into the subsurface bedrock, soil, or ice.

ASTID proposals are sought at three general levels: (i) feasibility study and instrument definition (i.e., proof of concept); (ii) instrument development and definition (i.e., the bread board stage); and (iii) development of instruments to a sufficiently mature "brass board" level that they may be proposed in response to future announcements of flight opportunities (flight opportunities include suborbital, orbital, planetary, and deep space platforms). Proposals to define or develop one or more instrument components, rather than whole instruments, are allowed, particularly for immature or very complex new instruments. However, at least one or more likely scenarios for possible follow-on instrument development activities must be described in the case of component-only proposals. Scientific objectives of proposed instruments or components must be discussed in the proposal, and proposers are encouraged to relate their proposals as closely as possible to future missions of interest to the Astrobiology program and demonstrate how the technology addresses Astrobiology goals and objectives.

## 1.3 Examples of Future Missions

Proposals for long-lead time definition studies, novel instrument concepts, and innovative approaches leading to new instrument classes that could be relevant to one or several missions will be considered. The following are examples of some, but not all, missions of interest to the Astrobiology program:

*Comet Missions.* The possibility exists that comets may have contributed critical amounts or specific prebiotic chemicals that may have been necessary for life on Earth and perhaps elsewhere in the Solar System. Therefore, proposals for instrument development for future missions to comets may include *in sit*u surface chemical analysis to determine and characterize the organic composition of gas, ice particles, and dust; the capability for sample return; and concepts for sampling the nucleus of a comet.

*Mars Missions.* Mars missions include orbiters and landers using small to medium sized spacecraft and launch opportunity windows that occur approximately every 26 months. The Mars Global Surveyor and 2001 Mars Odyssey are in orbit, and instrument investigations for the 2003 Mars Exploration Rovers and for the Mars Reconnaissance Orbiter have now been selected. Therefore, only instrument development proposals for Mars missions beyond the Mars 2005 mission are appropriate through this ASTID program element. Examples of relevant proposals include, but are not limited to, the development of:

- instrumentation capable of *in situ* isotopic measurement;
- microscale *in situ* technologies for detection and characterization of organic compounds;
- semiautonomous, deep, aseptic drilling and measurement systems to explore the subsurface and search for water;
- improved field analysis of "trace" or biomarker gases and biologically important solutes (e.g., nutrients), and
- physical/chemical factors that might be an indication of life.

*Outer Solar System Missions.* Possible missions to Europa include the Europa Orbiter, Europa Lander, Europa Ocean Observer, and Europa Lander Network. Instrument development proposals for the Europa Ocean Observer and Europa Landers are appropriate under this ASTID program element, for example:

- miniature *in situ* robotics and other instruments for icy bodies, including chemical and exobiological analyses;
- sample targeting, acquisition, and handling, including sampling of the dark linea, etc. surface features;
- orbital flight instruments to determine the inventory of organic compounds and biogenic elements on Europa's surface; and
- for the Europa Ocean Observer, which might include a penetrator for melting through the ice to reach the purported subsurface ocean, a "hydrobot" that could then be released to explore the ocean in search of biomarkers as possible evidence of life, characterization of the water column, and subsurface sediments.

The Cassini mission, which approaches Saturn in 2004, will lay the groundwork for any possible future Titan missions, including the planned Titan Biologic Explorer. Therefore, proposals are appropriate for instruments to search for and identify more complex organic molecules, for Titan atmospheric characterization, for characterization of the formation processes and products related to Titan's organic haze, and surface exploration.

*Astronomical Missions.* Some astrobiology objectives can be realized through astronomical observations of stars, extra-solar planets, and the interstellar medium. Therefore, proposals for instrument development for future astronomical opportunities, e.g., future SOFIA instruments, potential Explorer payloads, and instruments for Terrestrial Planet Finder, are welcome. However, proposals for development of astronomical instruments submitted to ASTID must focus on astrobiology objectives and not more general astronomical objectives..

### 1.4 Nonflight ASTID Goals

Although the focus of the ASTID program is development of scientific instruments for future flight opportunities, consideration will also be given to proposals for development of ground based laboratory or field instrumentation important to the goals and objectives of the Astrobiology program. Of particular interest will be instrumentation that would potentially enable new research capabilities for Astrobiology, such as the ability to measure novel biomarkers. Finally, instrument development proposals not explicitly mentioned above may be appropriate under this program element provided they address the goals and objectives of the Astrobiology Program.

## 2. Programmatic Information

### 2.1 Program Overlap

Currently, the Planetary Instrument Definition and Development Program (PIDDP) (Appendix A.2.11 in this NRA), also supports instrument development for potential future space flight to planets but by definition excludes instrumentation focused primarily on Astrobiology objectives. Therefore, proposals for development of instruments focused on Astrobiology should be submitted only to this ASTID program. NASA reserves the right to resolve any overlap of proposals submitted to PIDDP and ASTID program at the programmatic level at the time of selections. Proposers should be aware that each of these programs has different constraints, and proposals appropriate to one may not be appropriate to the other (for instance, the ASTID program will consider proposals for a broader timeframe than PIDDP, as well as laboratory instrumentation).

### 2.2 Size and Duration of Awards

Pending the final approval of NASA's Fiscal Year 2003 budget, up to one third of the program's budget ($3M) may be available for support of selections for the ASTID program. Awards are expected to range from $30K to $300K per year, for a maximum of

three years. Although proposals of up to three years may be submitted, NASA may select a mix of one and two year proposals in order to allow about one third of the ASTID program to be open for competition in every year.

## IMPORTANT INFORMATION

As discussed in the *Summary of Solicitation* of this NRA, the Office of Space Science (OSS) is now using a single, unified set of instructions for the submission of proposals. This material is contained in the document entitled *NASA Guidebook for Proposers Responding to NASA Research Announcement – 2001* (or *NASA Guidebook for Proposers* for short) that is accessible by opening URL http://research.hq.nasa.gov, and linking through the menu item "Helpful References," or may be directly accessed online at URL http://www.hq.nasa.gov/office/procurement/nraguidebook/. This NRA's Summary of Solicitation also contains the schedule and instructions for the electronic submission of a *Notice of Intent* (NOI) to propose and a proposal's *Cover Page/Proposal Summary*, which now also includes the required *Budget Summary*, and the mailing address for the submission of a proposal.

Questions about this program may be directed to the Discipline Scientist:

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